

HOW IT WORKS

The \$100 laptop

Most laptops are too fragile and expensive to be of use in the developing world. Simon Handby looks at how the One Laptop Per Child project aims to change that

Computers may be getting cheaper and faster all the time, but they're still very expensive in the developing world.

The One Laptop Per Child (OLPC) project is an attempt to make computers and the internet more accessible to people in poorer countries. Originating in the Massachusetts Institute of Technology's (MIT's) Media Lab, OLPC was set up as a non-profit organisation, with a mission to provide robust, simple and connected computers as learning tools for children in poorer countries.

Its highest-profile project is the development of the XO-1 laptop – a small, strong ultra-portable designed to be purchased in large quantities by governments and distributed to children. Commonly referred to as the \$100 laptop, the XO-1 first became available at the end of 2007 for \$188 (around £96). Mass production began in November 2007 and OLPC expects the price to fall as the manufacturing volumes increase in 2008.

Achieving such a low price has been quite an engineering challenge. A typical laptop costs far more than the low \$100 (£51) target price, and its comparatively fragile construction makes it ill-suited to the hot, sunny and basic environments common in many parts of the developing world. To meet both requirements, the XO-1's hardware is far from typical.

IMMOBILE COMPUTING

To minimise the chance of a failure in places where repairs might be hard to come by, the notebook contains no moving parts. This rules out the spinning platters and moving heads of a hard disk, so instead the operating system and user files are stored on 1GB of built-in flash memory, with an external SD card slot providing scope for expansion. There's no optical or floppy drive, but the SD slot can be used to install third-party applications.

AMD makes the XO-1's processor, although it's much less powerful than the Turion processors you might expect to find in a modern laptop. The Geode LX 700 uses considerably less power, too, running at a maximum of 433MHz with a typical consumption of just 1.3W. The graphics controller is integrated with the processor, removing the need for a dedicated device that consumes more power. There's 256MB of 333MHz DDR memory, and the memory controller is also integrated into the processor.

With no hard disk, and two typically power-hungry and hot chips combined into a single processor, the laptop produces comparatively little heat. This is essential, as the design requirement for doing away with moving parts rules out cooling fans. What's more, the laptop has to survive in hot and dusty or sandy environments. Its case has no air vents at all, and

the heat generated by its components has to dissipate through the sealed plastic case.

SCREEN BURN

Although much of the XO-1 is unconventional, its 7.5in widescreen display is particularly innovative. A typical laptop screen costs tens of dollars to manufacture and is illuminated from behind by one or more cold cathode fluorescent lamps (CCFL), which may use several watts when operating. The white light they generate passes through a colour filter that tints light in very small dots (sub-pixels) of red, green and blue. Each group of three coloured dots together makes up one pixel.

A liquid crystal layer placed on top of the filter can selectively block each tiny coloured square, or allow some or all of its light to shine through to the front of the screen. By controlling the brightness of the red, green and blue components of each pixel in this way, the pixels' overall colour and brightness can be controlled from thousands of possibilities, producing a detailed colour image on the screen.

Even at full brightness, however, CCFL lamps can't provide enough light to make a notebook's screen legible in very bright light, and as much as 85 per cent of the light they produce is absorbed by the colour filter. To get round this, the XO-1's screen uses a diffraction layer instead, which splits white light into a spectrum of its component colours in much the same way that a clear glass prism does.

The diffraction layer's precision pattern, which is stamped using the same process used in commercial DVD production, allows it to direct the red, green and blue light components into exactly the right places on the screen.

ON REFLECTION

Because the XO-1's intended market includes equatorial countries with very powerful sunlight, its screen has a second mode that works using reflected ambient light. In dark or moderately lit conditions, an additional, semi-reflective layer sandwiched between the diffraction and liquid crystal layers allows the diffracted, coloured light from the backlight to pass through normally. However, any ambient light falling on the screen is bounced back through the liquid crystal by the semi-reflective layer and towards the user.

Unlike a normal LCD, where coloured sub-pixels are arranged in a repeating pattern of red, green and blue blocks in sets that constitute single pixels, the coloured blocks of the XO-1's screen are arranged in a diagonally staggered pattern. Each is regarded as an individual pixel, even though it takes a group of three to produce a full-colour dot on the screen.

Thanks to this approach, reflected ambient light, which doesn't pass through the diffraction

layer and get split into colours, produces a greyscale image at the LCD's full 1.1-megapixel (1,200x900) resolution. When there's no ambient light, each of the display's backlit pixels is a shade of either red, green or blue, giving the screen a colour image at a third of the resolution – around 360,000 (693x520) pixels.

Perhaps the best way to understand this is to imagine a normal 1,280x1,024 LCD screen, which contains 1.3 million pixels. Each pixel consists of red, green and blue sub-pixels, so if you took a black-and-white photo, the screen would appear to have a resolution of nearly four million pixels.

By not regarding each coloured pixel as a sub-pixel, the screen can switch seamlessly between backlit and non-backlit operation, making the most of available light to save power. OLPC says that in most lighting conditions the display works in a combination of greyscale and colour, producing a colour picture with a perceived resolution of between 800x600 and 1,024x768 pixels. However, because the amount of ambient light and the notebook's backlight affect both the screen's colour and perceived resolution, OLPC's wiki advises software developers to check that their user interfaces work in both full-colour and greyscale modes.

The XO-1 uses a white LED light source as a backlight, which uses less power than a CCFL. This can be turned off altogether when ambient light is available. The screen also has an innovative controller chip that caches the displayed image, often allowing the processor to shut down to save power while the screen remains on. OLPC describes the display as the basis of the laptop's extremely low power architecture, and says that huge power savings are made by turning off devices on the motherboard when they are not in use (even for a few seconds), while keeping the display on. It says that with the LED backlight on, power use is less than 1W. With it off, the screen's power use is a miserly 0.1-0.2W.

NET BENEFIT

Because OLPC anticipates that the XO-1 will be used in regions with little or no IT infrastructure, the laptop has clever wireless capabilities.

It has two rubber and polycarbonate 'bunny ear' antennas, which fold open to increase wireless range, revealing USB and audio ports protected from dust beneath. Although the antennas have been drop-tested from desk height, the laptop can function if one is broken, and they are designed to be replaceable.

Unlike a regular wireless controller, the laptop's Marvell 88W8388 wireless chipset contains a custom ARM processor, which allows it to handle wireless traffic without the main processor. The laptop can stop and start its

\$100 view The XO-1's new features

Built for educational use in developing countries, the XO-1 is designed to be tough and have a range of control options

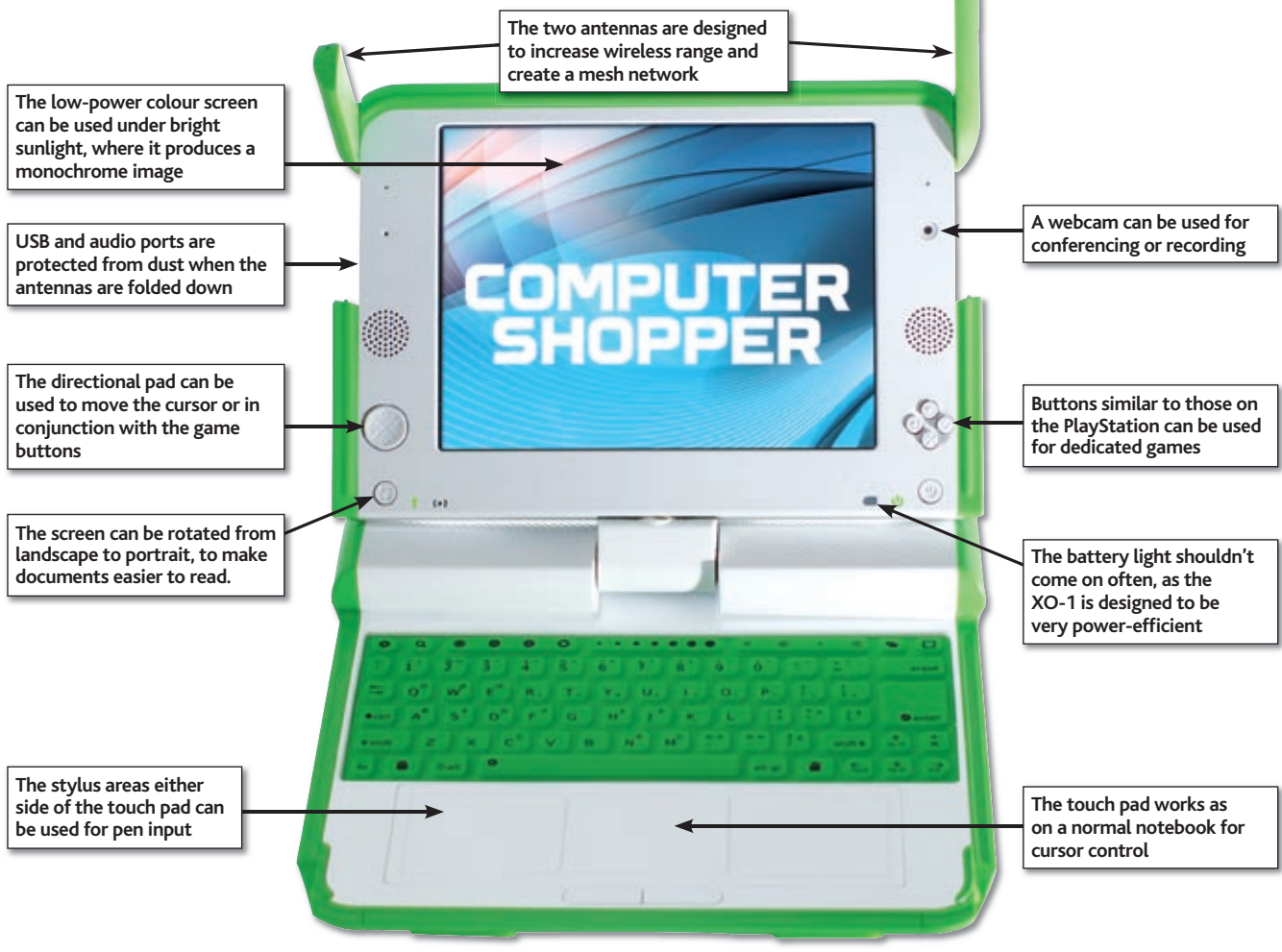


IMAGE SOURCE: WIKIPEDIA.ORG

processor freely to conserve power, but this won't disrupt the network connection.

Regular 802.11g wireless networks are unlikely to be available in places where people are using this laptop, so the wireless chip also implements what OLPC describes as "self-organising multihop" or mesh networking, which it says is close to the 802.11s draft protocol. This enables several XO-1 laptops to create ad hoc network groups automatically when they're within range of one another, without requiring the user to configure them.

The OLPC project focuses on schools, with the intention of providing all the pupils in a school with a laptop. The school should also have a server that provides internet connectivity and additional storage space. When initialised, the XO-1's wireless chip looks for an existing mesh of interconnected laptops to join, trying wireless channels 1, 6 and 11.

If none is found, it searches for an access point (AP). If this connection is successful, the notebook is able to act as a mesh portal (MPP), where it can route traffic to and from other laptops that are within its range but not within direct range of the AP. In this way it is hoped that multiple laptops can increase the coverage and availability of each AP.

Here, the wireless chip's ability to run while the laptop is totally powered down helps to maximise the coverage of each meshed group of computers. If one child shuts down their

computer, it still functions as a router using just 0.5W; while the battery or power source lasts, others further along the chain needn't lose their connection. With a battery rated at 16.5 watt-hours or above, the connection can be maintained for more than a day.

Finally, if the wireless chip finds no existing mesh and no AP, it configures the laptop to be the first node on a new mesh.

FINAL TOUCH

The OLPC project is not without its critics, who argue that developing nations should spend their money on elementary infrastructure before technology. There has also been upheaval, with Intel joining the already well-established project in July 2007, only to leave in early 2008.

At the time of writing, the XO-1's rubber membrane keyboard was the subject of a \$20 million law suit in Nigeria that had prevented its legal sale there. However, the laptop's unique touch pad is probably the more interesting piece of hardware. The dual-mode pad has a conventional capacitor-sensor central section that responds to fingertip movements. Overlapping it is a wider, resistive-sensor region for use with a pen, allowing handwritten input.

Early trials, most notably in Peru, suggest that the laptop does bring real benefits to communities in the developing world. There's considerable interest in the developed world, too, with many customers in the US recently paying

\$399 (around £200) into a 'give one, get one' scheme. For this money, OLPC ships one XO-1 to the donor and a second to a child in a developing nation.

The laptop's development also seems to have stimulated established manufacturers to market simple ultra-portables at previously unimaginable prices. At £209, Asus's excellent Eee PC 701 (see *What's New, Shopper* 240) is one example. Like the XO-1, the diminutive Asus uses a solid-state hard disk and runs a version of Linux.

However successful the XO-1 proves in the US and Europe, though, the project's single-minded approach to power-saving, ruggedness and collaborative working make the laptop so well suited to its intended role that it's hard to imagine it failing in the developing world. **CS**

FURTHER INFORMATION

OLPC homepage <http://laptop.org>

OLPC wiki – detailed specs and information <http://wiki.laptop.org/go/Home>

Wikipedia entry on XO-1 http://en.wikipedia.org/wiki/OLPC_XO-1

Wikipedia entry on IEEE 802.11s mesh networking draft http://en.wikipedia.org/wiki/IEEE_802.11s

Groklaw article on Nigerian keyboard law suit <http://tinyurl.com/2sbtrs>

MIT Media Lab www.media.mit.edu